



US007583855B2

(12) **United States Patent**
Dundar et al.

(10) **Patent No.:** **US 7,583,855 B2**
(45) **Date of Patent:** **Sep. 1, 2009**

(54) **SIGNAL SOURCE DATA INPUT FOR RADIO FREQUENCY PLANNING**

(75) Inventors: **Baris Dundar**, San Pablo, CA (US);
Raymond Rui-Feng Liao, Pleasanton, CA (US)

(73) Assignee: **Siemens Aktiengesellschaft**, Munich (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 677 days.

(21) Appl. No.: **11/361,142**

(22) Filed: **Feb. 23, 2006**

(65) **Prior Publication Data**

US 2007/0197225 A1 Aug. 23, 2007

(51) **Int. Cl.**
G06K 9/36 (2006.01)

(52) **U.S. Cl.** **382/276; 342/360**

(58) **Field of Classification Search** **342/359, 342/360; 343/700 R, 755, 912; 700/125, 700/182; 706/919; 715/964**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

- 5,394,522 A 2/1995 Sanchez-Frank et al.
- 5,450,615 A 9/1995 Fortune et al.
- 5,640,002 A 6/1997 Ruppert et al.
- 5,686,705 A 11/1997 Conroy et al.
- 5,732,077 A 3/1998 Whitehead
- 5,949,988 A 9/1999 Feisullin et al.
- 5,953,669 A 9/1999 Stratis et al.
- 6,059,842 A 5/2000 Dumarot et al.
- 6,119,009 A 9/2000 Baranger et al.
- 6,317,599 B1 11/2001 Rappaport et al.
- 6,330,429 B1 12/2001 He
- 6,336,035 B1 1/2002 Somoza et al.
- 6,337,688 B1 1/2002 Berstis

- 6,360,107 B1 3/2002 Lin et al.
- 6,393,290 B1 5/2002 Ufongene
- 6,500,123 B1 12/2002 Holloway et al.
- 6,522,888 B1 2/2003 Garceran et al.
- 6,654,612 B1 11/2003 Avidor et al.
- 6,759,979 B2 * 7/2004 Vashisth et al. 342/357.13
- 6,885,191 B1 4/2005 Gleman

(Continued)

FOREIGN PATENT DOCUMENTS

EP 1175115 A2 * 1/2002

(Continued)

OTHER PUBLICATIONS

K. E. Oliver: "Introduction to Automatic Design of Wireless Networks"; ACM Crossroads 11.4: Mobile and Wireless Networking, (online) Jun. 2005, Retrieved from the internet: <http://www.acm.org/crossroads/xrds11-4/automaticdesign.html>.*

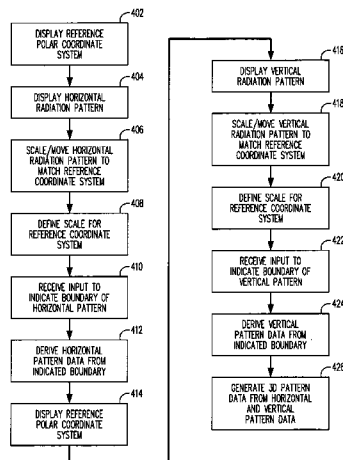
(Continued)

Primary Examiner—Matthew C Bella
Assistant Examiner—Gregory F Cunningham

(57) **ABSTRACT**

A method includes displaying a reference polar coordinate system on a display screen, and displaying a radiation pattern image on the display screen in juxtaposition with the displayed reference polar coordinate system. In another aspect, an angled line is drawn on a display screen to represent the proposed layout of a leaky coaxial cable. A point of interest is selected that is spaced from the proposed cable layout, and one of the segments of the cable is determined as likely to produce a dominant level of irradiation with respect to the point of interest.

19 Claims, 10 Drawing Sheets



U.S. PATENT DOCUMENTS

7,299,168 B2 * 11/2007 Rappaport et al. 703/20
2004/0181374 A1 9/2004 Rappaport et al.
2007/0106717 A1 5/2007 Dundar et al.
2007/0196227 A1 8/2007 Dundar et al.
2008/0075051 A1 3/2008 Dundar et al.

FOREIGN PATENT DOCUMENTS

WO WO 98/03025 A1 1/1998
WO WO 99/30448 A1 6/1999
WO WO 02/10942 A1 2/2002

OTHER PUBLICATIONS

Iwama T, et al.: "Investigation of Propagation Characteristics above 1 GHz for Microcellular Land Mobile Radio"; May 6, 1990; pp. 396-400.
H. HE J. McDowell & M. Conroy; "asc coordinate transformation the pixlib library, II" Astronomical Data Analysis Software Systems VII, APS Conference Series; vol. 145, 1998; pp. 1-4.
U.S. Appl. No. 11/324,167, filed N/A, Dundar, et al.

Florence Sagnard, "The Matlab Graphical Interface Ecamo", Internet Publication, (online) Jul. 5, 2002, Retrieved from the internet: http://www.univ-mlv.fr/crmo/interfaces/ECAMO/fiche_ecamo_0801.pdf.
William C. Y. Lee: "Wireless and Cellular Communication (part)" Book, Oct. 22, 2005, pp. 396-402.
K. E. Oliver: "Introduction to Automatic Design of Wireless Networks"; ACM Crossroads 11.4: Mobile and Wireless Networking, (online) Jun. 2005, Retrieved from the internet: <http://www.acm.org/crossroads/xrds11-4/automaticdesign.html>.
G. Bianchi, "Performance Analysis of the IEEE 802.11 Distributed Coordination Function", IEEE Journal of Selected Areas in Communication, 18(3), Mar. 2000, pp. 535-547.
A. Veres. et al., "Supporting Service Differentiation in Wireless Frame Networks, Using Distributed Control", IEEE Journal of Selected Areas in Communication, 19(10), Oct. 2001, pp. 2081-2093.
Steven J. Fortune, et al., "Wise Design of Indoor and Outdoor Wireless Systems: Practical Computation and Optimization", IEEE Computational Science & Engineering, Spring 1995, Lucent Bell Labs, pp. 58-68.
* cited by examiner

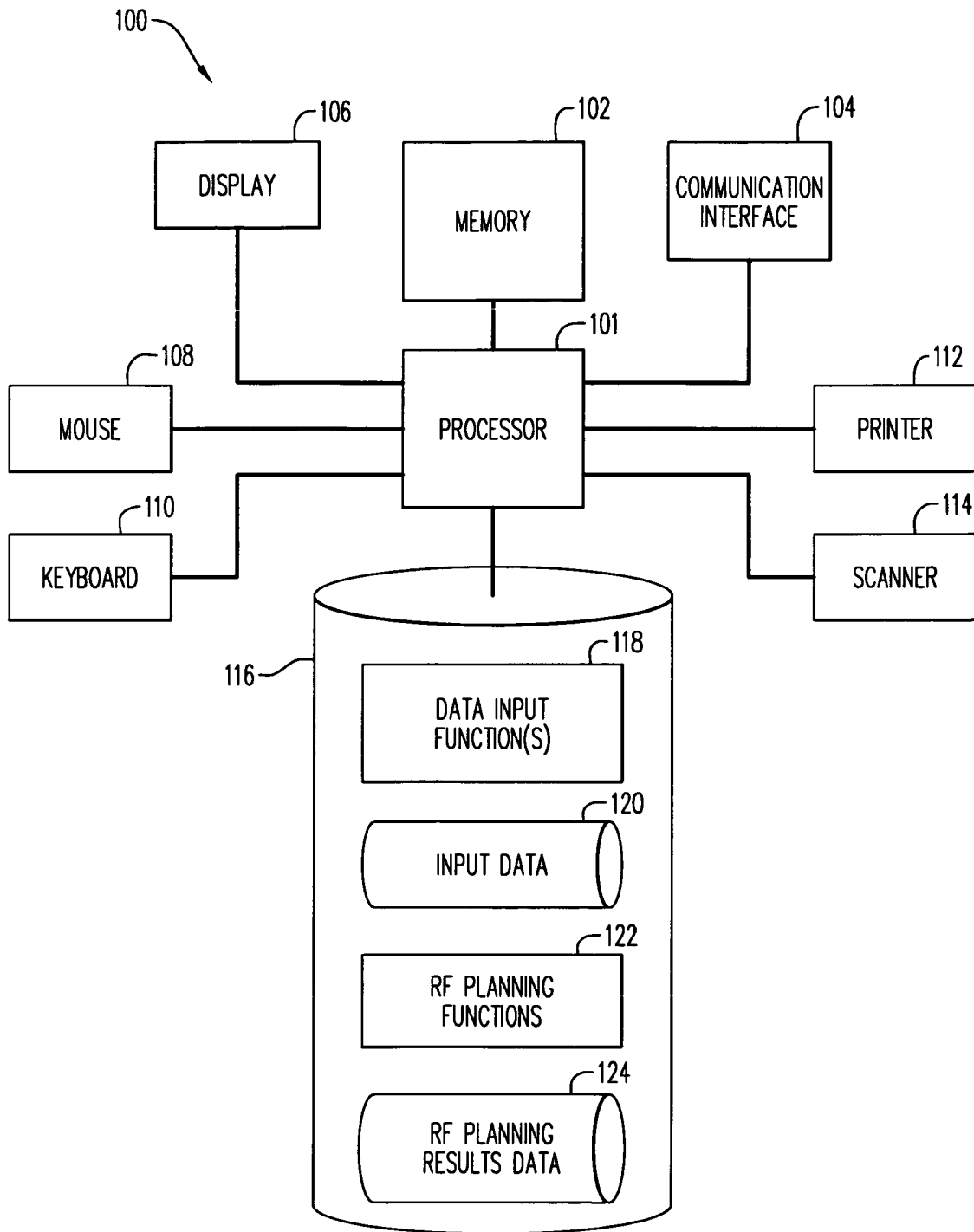


FIG. 1

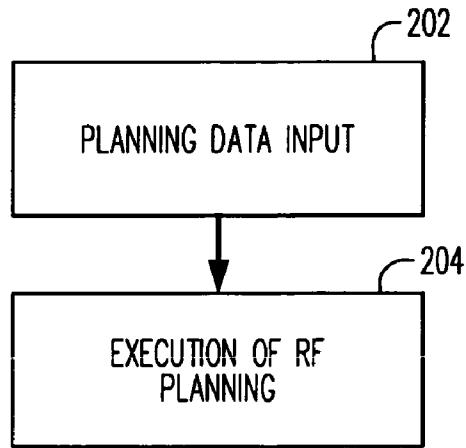


FIG. 2

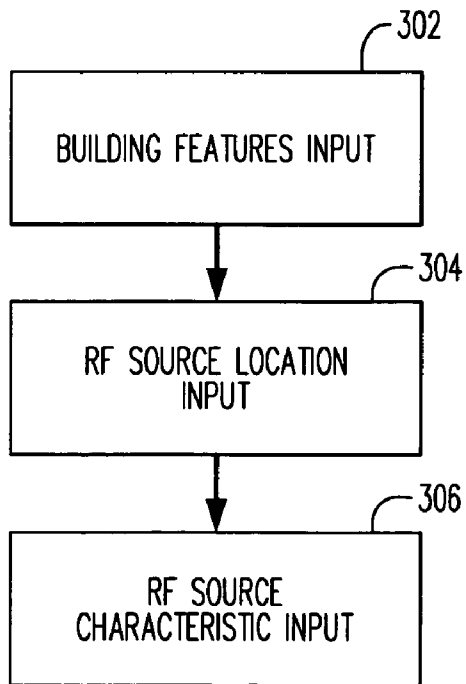


FIG. 3

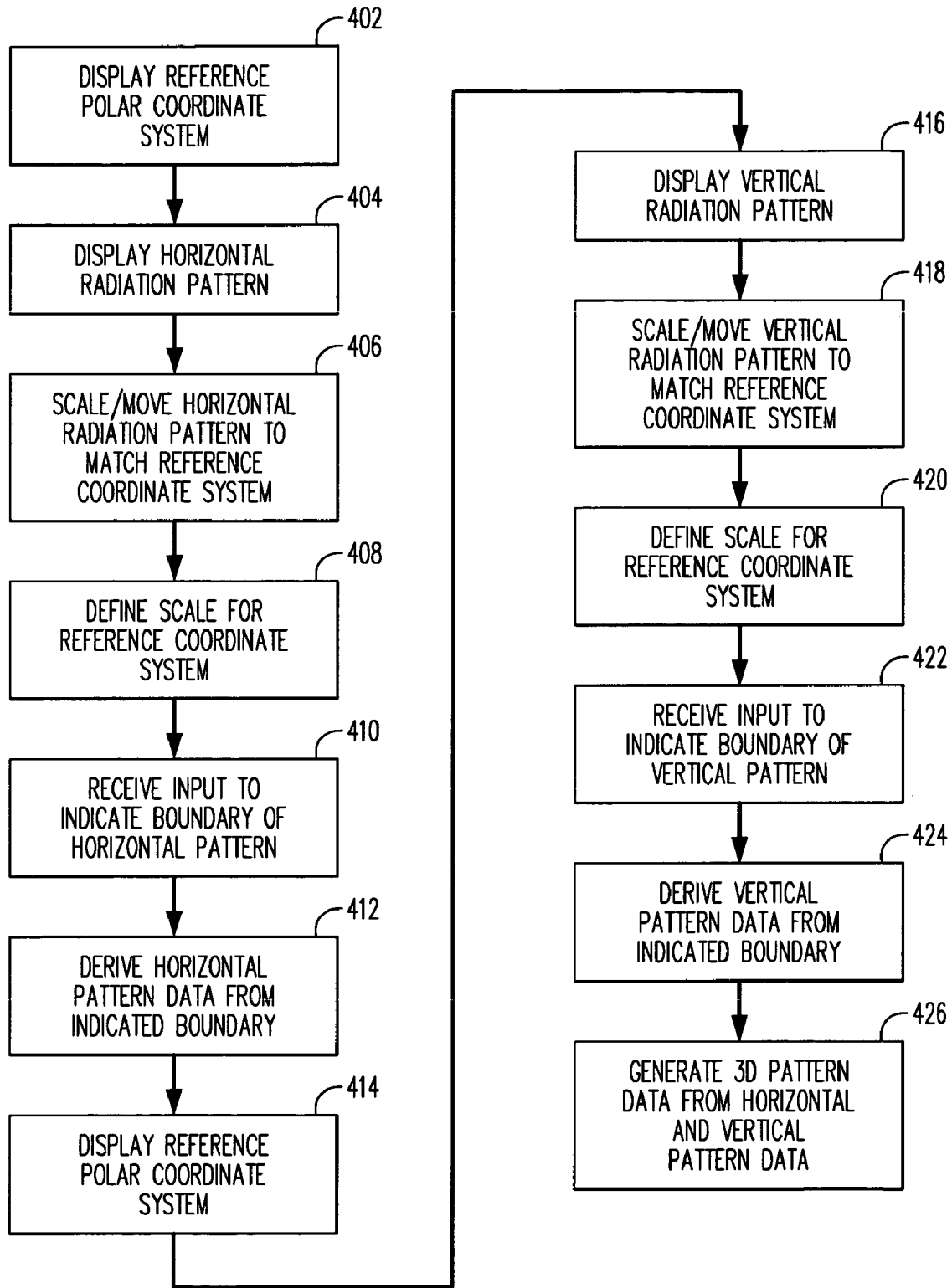


FIG. 4

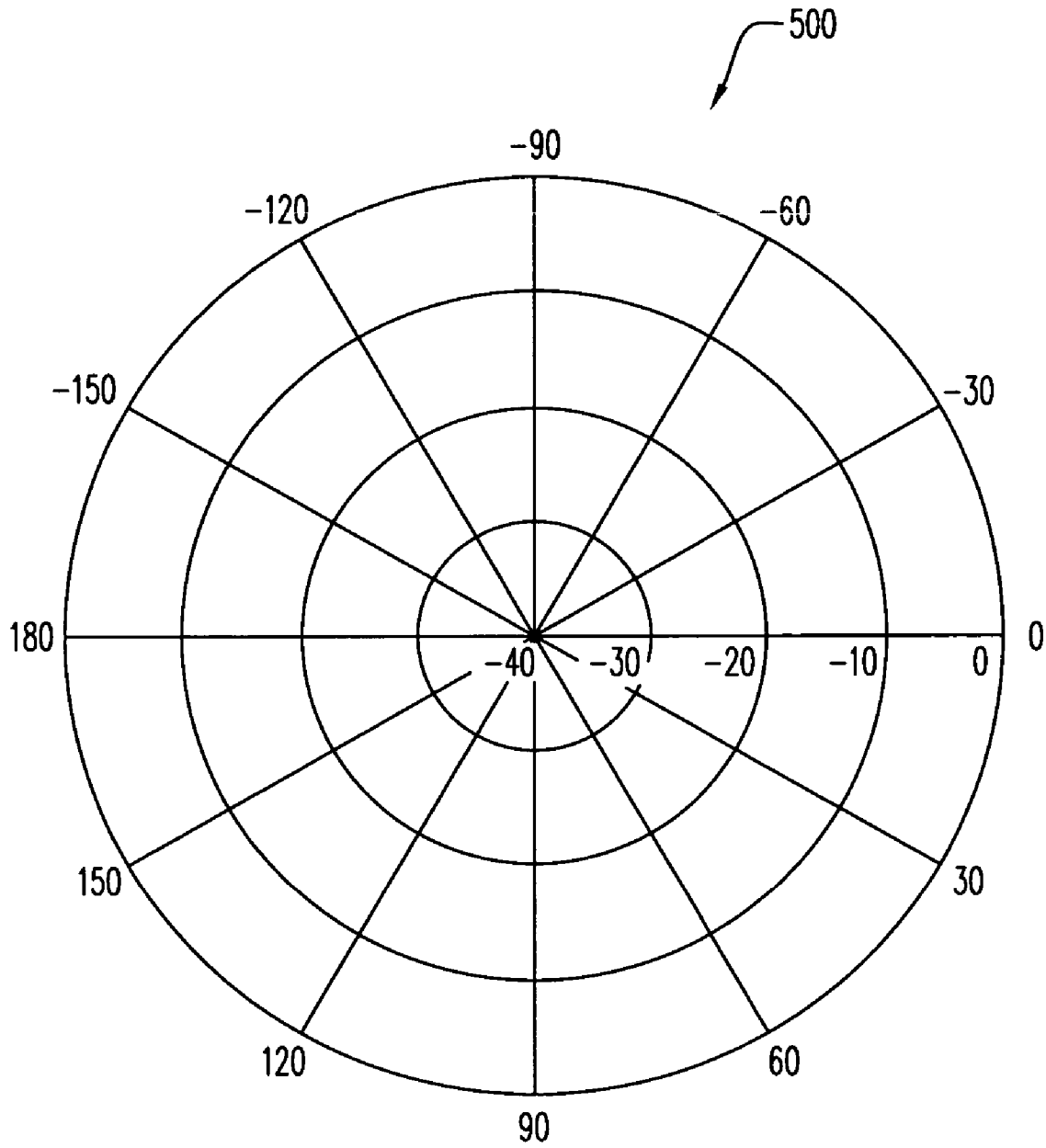


FIG. 5

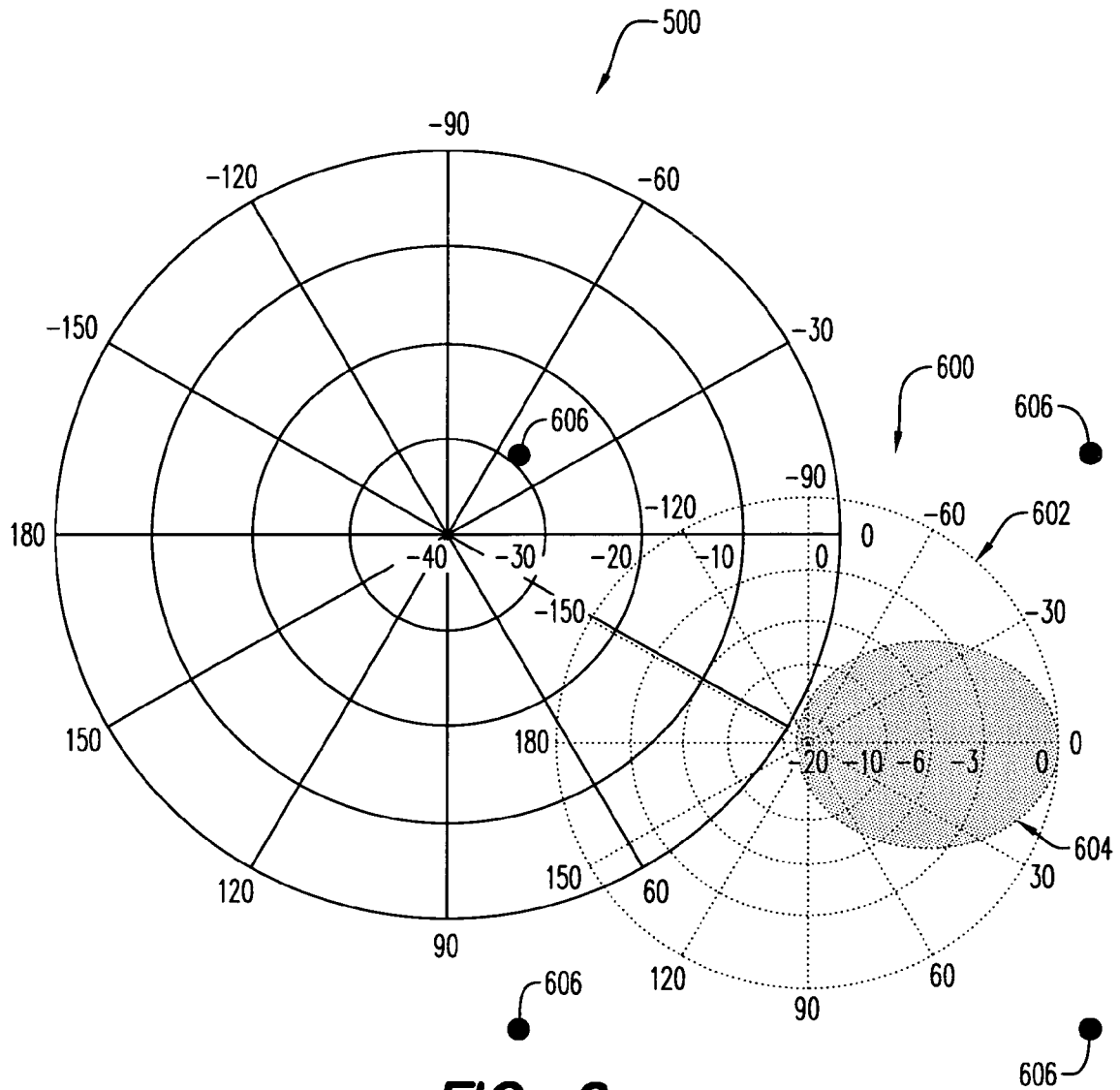


FIG. 6

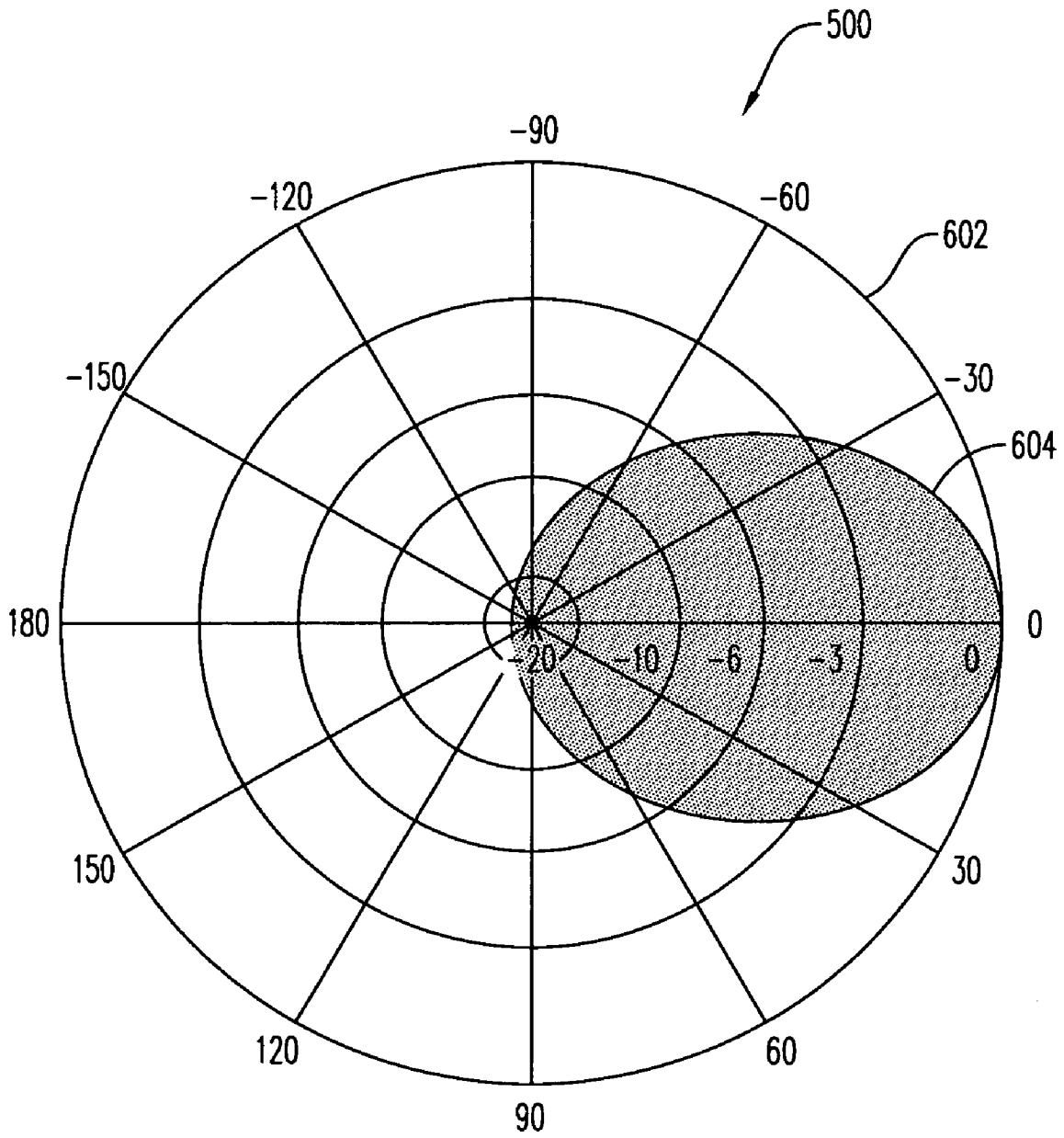


FIG. 7

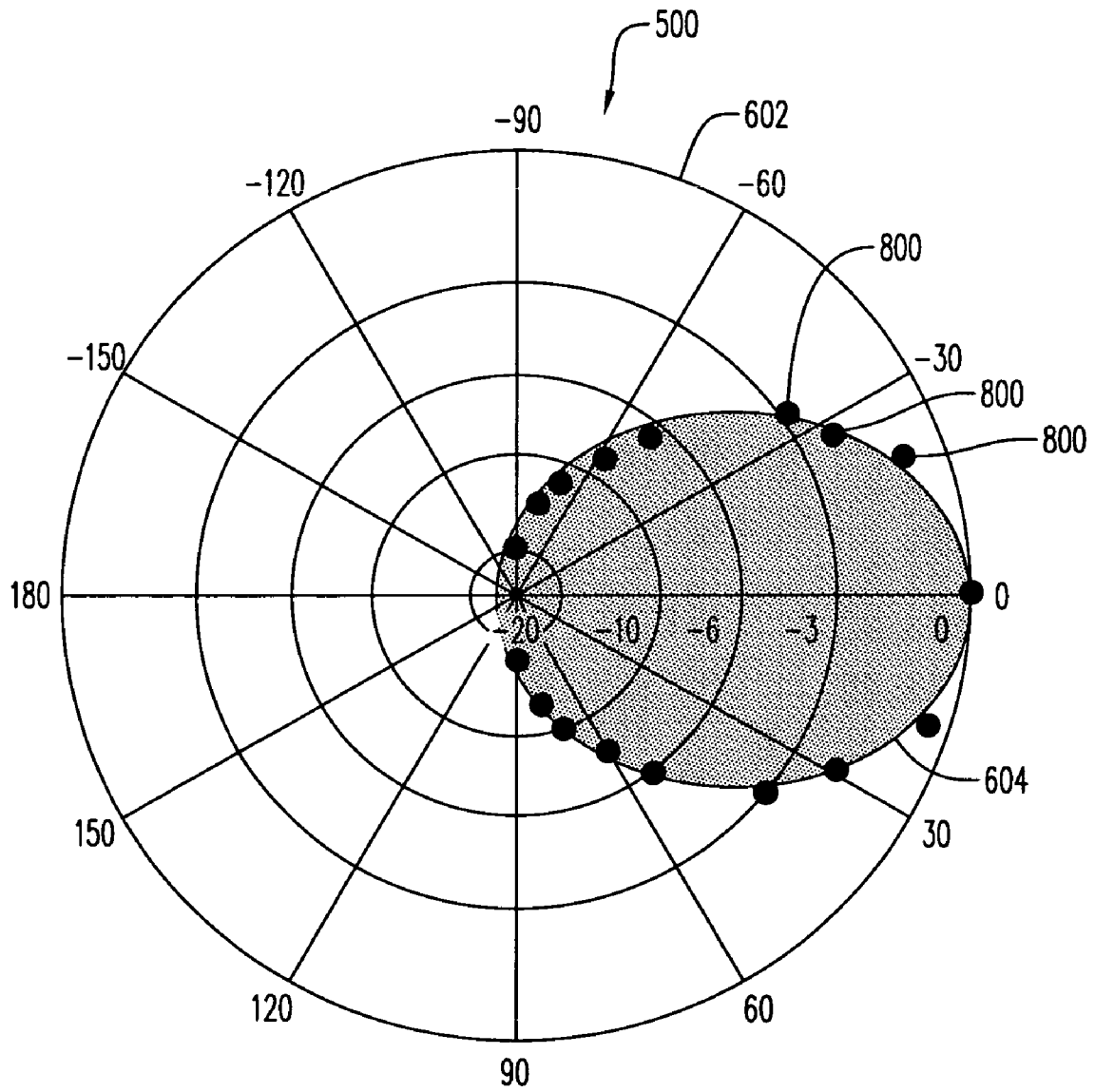


FIG. 8

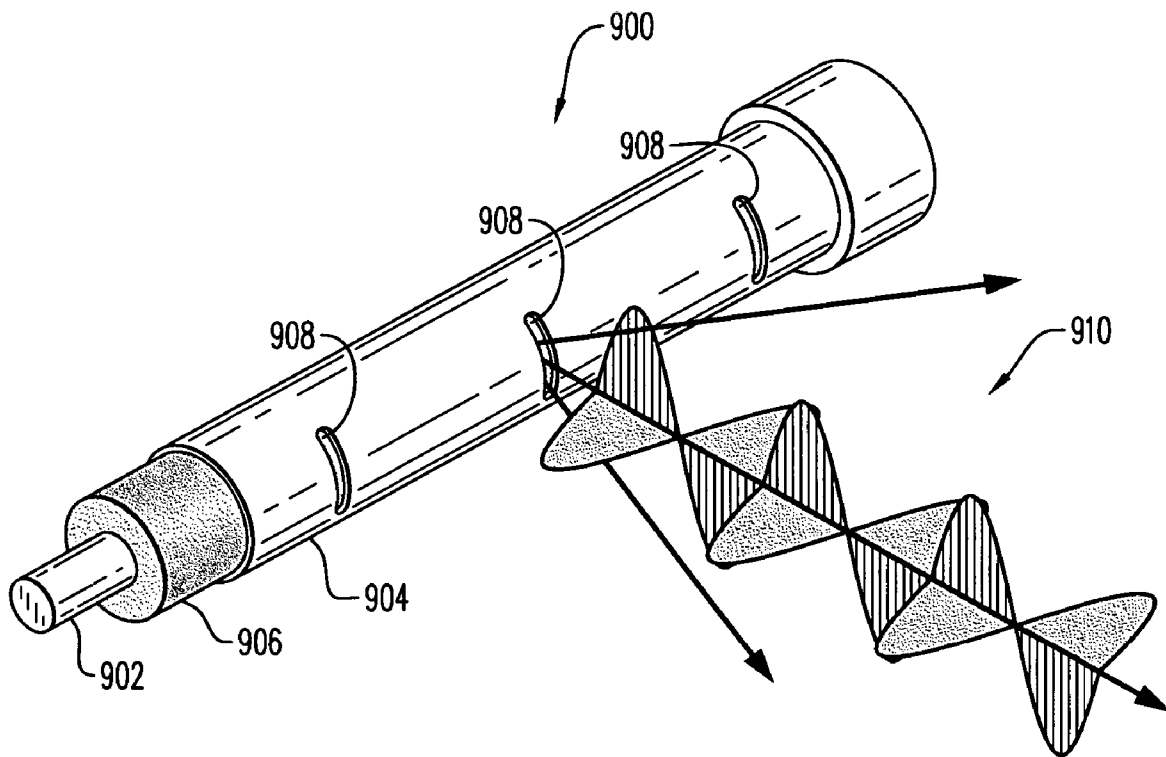


FIG. 9

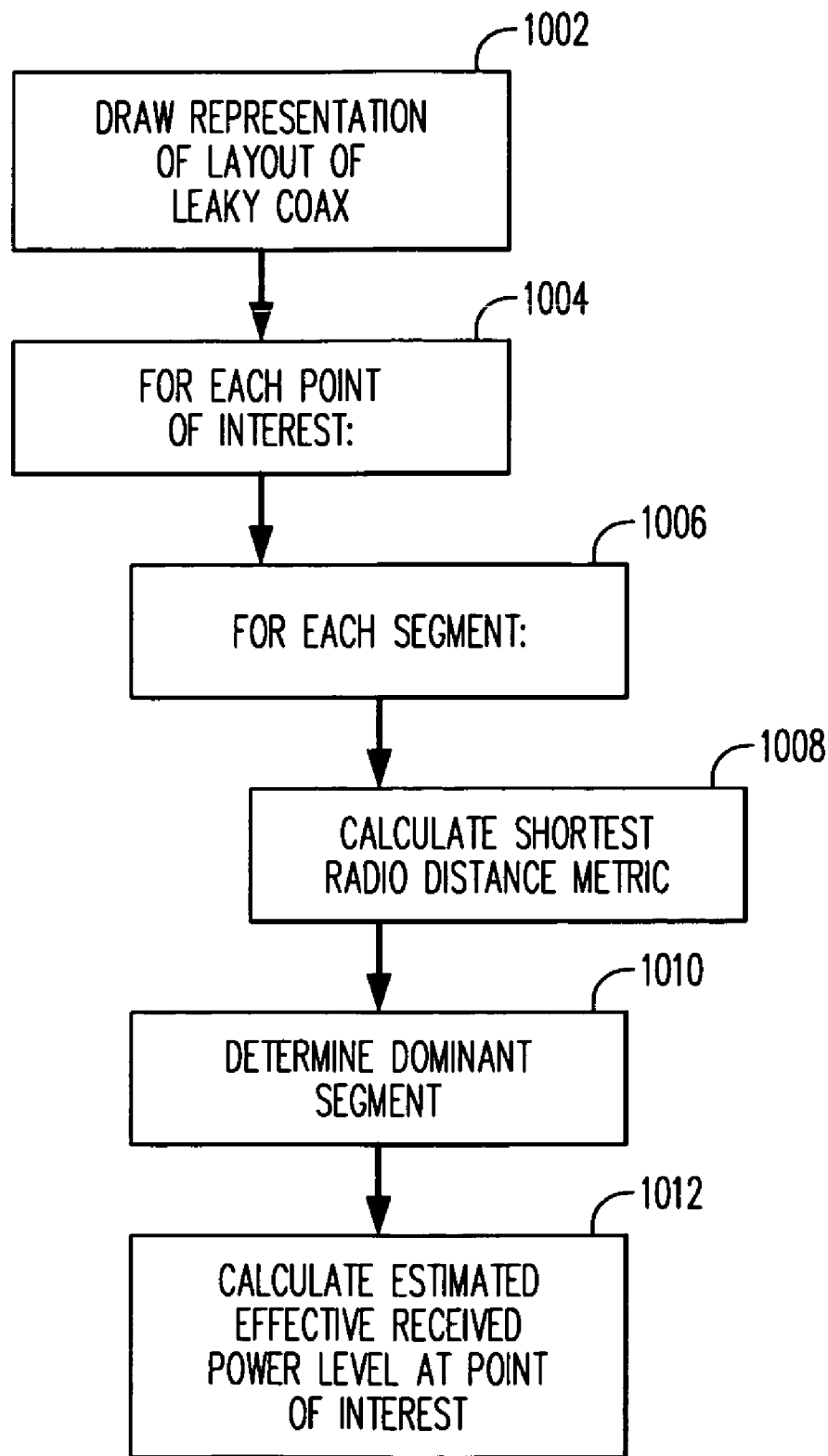


FIG. 10

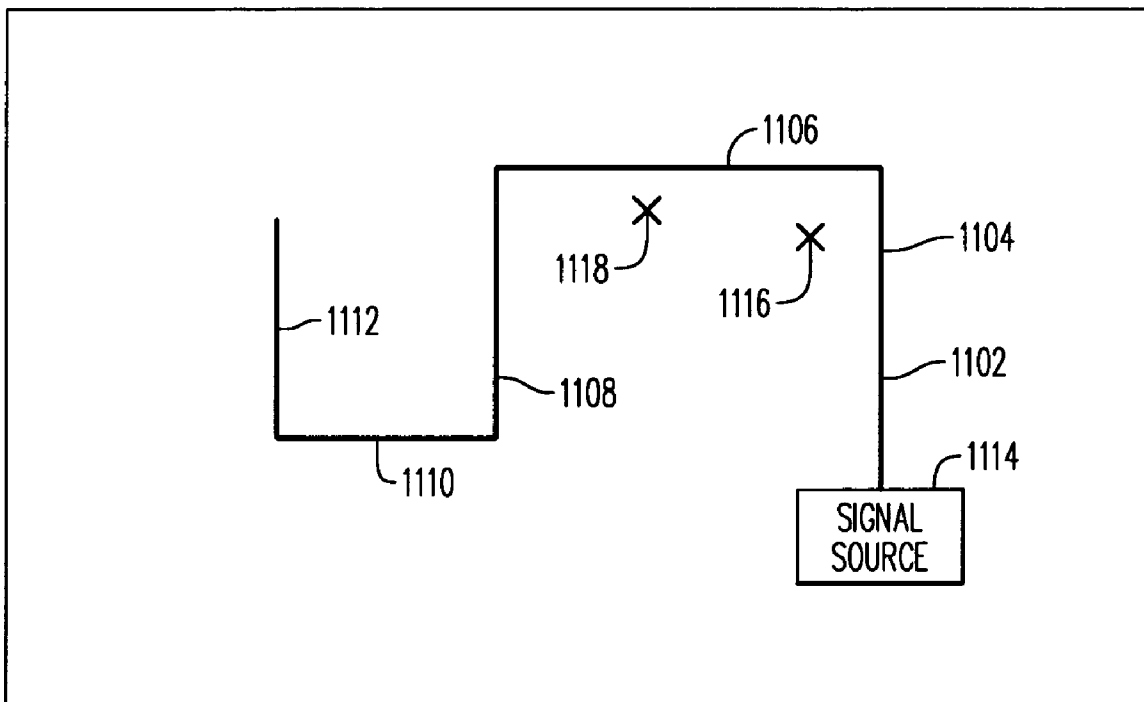


FIG. 11

SIGNAL SOURCE DATA INPUT FOR RADIO FREQUENCY PLANNING

BACKGROUND

Radio frequency (RF) planning is frequently a part of plans to deploy a large-scale wireless local area network (LAN). The purpose of RF planning is to ensure an adequate quality of RF signal coverage across the area in which the wireless LAN is to be deployed. Data to be considered for RF planning includes signal-to-noise ratio (SNR) and signal-to-noise-plus-interference ratio (SINR).

Conventional RF planning efforts generate data that indicates the locations of building features, relevant objects, and planned and/or existing sources of RF signals within a building. It may also be important for the planning process to take into account information regarding the radiation patterns of the signals provided by the signal sources. However, it can be inconvenient to provide such information as an input to the RF planning function.

SUMMARY

The present invention generally relates to planning of wireless communication networks. In particular, apparatus and methods are presented for inputting to an RF planning system information concerning the signal radiation patterns of signal sources.

According to some embodiments, a method, an apparatus and an article of manufacture that includes a computer usable medium containing computer readable program code are provided. The method steps and/or the steps performed by the apparatus and/or the steps called for by the computer readable program code include displaying a reference polar coordinate system on a display screen, and displaying a radiation pattern image on the display screen in juxtaposition with the displayed reference polar coordinate system.

In some embodiments, the method steps further include receiving input to indicate a location of the radiation pattern relative to the displayed polar coordinate system. The receiving step may include displaying a cursor at a boundary of the radiation pattern and, while displaying the cursor at the boundary, receiving an indication of actuation of a pointing device such as a mouse. The actuation may be clicking of a button on the mouse.

In another aspect, the method steps may include displaying a first polar coordinate system on a display screen; displaying a first radiation pattern image on the display screen, where the first radiation pattern image includes a second polar coordinate system and a first pattern region indicative of a radiation pattern generated by an antenna in a horizontal plane; scaling and moving the first radiation pattern image to bring the second polar coordinate system into coincidence with the first polar coordinate system; defining a scale for the first polar coordinate system to reflect a parameter of the first radiation image; marking points on a boundary of the first pattern region; deriving horizontal pattern data from the marked points; displaying a second radiation pattern image on the display screen together with the first polar coordinate system at a time when the first radiation pattern image is not displayed on the display screen, where the second radiation pattern image includes a third polar coordinate system and a second pattern region indicative of a radiation pattern generated by the antenna in a vertical plane; scaling and moving the second radiation pattern image to bring the third polar coordinate system into coincidence with the first polar coordinate system; defining a scale for the first polar coordinate system

to reflect a parameter of the second radiation pattern image; marking points on a boundary of the second pattern region; deriving vertical pattern data from the points marked on the boundary of the second pattern region; and generating three-dimensional pattern data from the horizontal and vertical pattern data.

In some embodiments, the method steps further include providing the three-dimensional pattern data as an input to an RF planning function for a wireless data network. The steps for marking points may include clicking a mouse button when a cursor is located on the boundary of the first or second pattern region. The second radiation pattern image may be displayed after the marking of points on the boundary of the first pattern region, or the first radiation pattern image may be displayed after the marking of points on the boundary of the second pattern region.

In still another aspect, the method steps include using a computer-drawing function to draw, on a display screen, an angled line formed of a plurality of straight segments. The angled line represents a proposed layout of a leaky coaxial cable. Each segment represents a respective cable segment of the cable. The method steps further include selecting a point of interest spaced from the proposed layout of the cable, and determining which one of the cable segments is likely to produce a dominant level of irradiation with respect to the point in space.

In some embodiments, the determining step includes determining for each cable segment a shortest radio distance metric with respect to the point of interest. Determining the shortest radio distance metric includes determining a closest point on the cable segment in question to the point of interest. Determining the shortest radio distance metric further includes calculating first signal attenuation along the cable from a start point to the closest point on the cable segment, and calculating second signal attenuation resulting from spatial separation between the point of interest and the closest point on the cable segment in question.

In some embodiments, the method steps further include calculating an estimated effective received power level at the point of interest. The estimated effective received power level may be calculated by subtracting from an input power level at the start point: (a) the first signal attenuation along the cable from the start point to the closest point on the determined one of the cable segments; (b) the second signal attenuation resulting from spatial separation between the point of interest and the closest point on the determined one of the cable segments; and (c) a coupling loss constant for the cable. The method steps may also include providing the calculated estimated effective received power level as an input to an RF planning function for a wireless data network.

Further aspects of the instant system will be more readily appreciated upon review of the detailed description of the preferred embodiments included below when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a computer in which the invention may be embodied;

FIG. 2 is a high level flow chart that illustrates a process that may be performed in the computer of FIG. 1;

FIG. 3 is a flow chart that shows some details of the process of FIG. 2;

FIG. 4 is a flow chart that shows further details of the process of FIGS. 2 and 3;

3

FIGS. 5-8 illustrate portions of a graphical user interface that may be displayed by the computer of FIG. 1 as a part of the process of FIG. 4;

FIG. 9 is a partial schematic illustration of a "leaky" coaxial cable that may be modeled in the process of FIGS. 2 and 3;

FIG. 10 is a flow chart that shows further details of the process of FIGS. 2 and 3; and

FIG. 11 illustrates portions of a graphical user interface that may be displayed by the computer of FIG. 1 as part of the process of FIG. 10.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

According to some embodiments, RF planning information is input into a computer using graphical user interfaces. One such interface, used to model a point-source antenna, allows an image representation of the antenna's radiation pattern to be superimposed on a reference polar coordinate system. By user input (e.g., via a mouse) the outline of the radiation pattern is indicated with reference to the reference polar coordinate system, and the resulting data is used by the computer as an input to an RF planning process for a wireless data network or the like.

Another such interface is used to model a leaky coaxial cable that may be proposed as a signal source in the wireless data network. A computer drawing tool allows the user to sketch a line-segment representation of the layout of the leaky coaxial cable. From this representation, the computer calculates estimated effective received power levels at points of interest in the area to be covered by the wireless data network.

With either or both of those data input techniques, inputting data to a computer for RF planning is simplified and made more convenient.

FIG. 1 is a block diagram of a computer 100 as provided in accordance with some embodiments. The computer 100 may, for example, implement some or all of the RF planning data input functions described below. The computer 100 may, in some embodiments, be entirely conventional in terms of its hardware aspects. For example, the computer 100 may, in its hardware aspects and some of its software, be a conventional personal computer. As indicated in this paragraph and discussed further below, software may be provided to control the computer 100 in accordance with aspects of the present invention, and data may be stored and manipulated in the computer 100 in accordance with aspects of the present invention.

The computer 100 may include one or more processors 101, which may be a conventional microprocessor or microprocessors. Also included in computer 100 is memory 102 that is in communication with the processor 101. The memory 102 may be, in some embodiments, one or more of RAM, ROM, flash memory, etc., and may serve as one or more of working memory, program storage memory, etc.

In some embodiments, the computer 100 may also include a communication interface 104. The communication interface 104 may, for example, allow the computer 100 to access information via the Internet. In addition or alternatively, some or all of the data required for the processes described below may be provided to the computer 100 via one or more storage media such as floppy disks, CD-ROMs, etc. Media drives for such media may be included in the computer 100 but are not separately shown.

As seen from the drawing, the computer 100 may also include a number of different input/output devices, including devices needed to present a graphical user interface (GUI) to

4

a user of the computer. In particular, the computer 100 may include a display screen 106, which may be, for example, a conventional flat panel display or CRT computer monitor. A further feature of the GUI, also included in the computer, is a conventional pointing device 108 such as a mouse, trackball, touchpad, etc. (As used herein and the appended claims, the term "mouse" shall be understood to include any one or more of the pointing devices referred to in the previous sentence.) The computer may further include a conventional computer keyboard 110, and a conventional printer 112, which may be used to print out results of an RF planning function to be described below.

A further peripheral device that may be part of the computer 100 is a conventional scanner 114. The scanner 114 may be used, for example, as a source of one or more antenna radiation pattern images that may be used, as described below, as part of the data entry function of the present invention.

Also included in the computer 100, and in communication with the processor 101, is a mass storage device 116. Mass storage device 116 may be constituted by one or more magnetic storage devices, such as hard disks, one or more optical storage devices, and/or solid state storage. The mass storage 116 may store software 118 which controls the computer 100 to present a GUI by which a user may enter data to be used in an RF planning process. The resulting data may be stored in one or more data storage structures 120 maintained in the mass storage 116. The mass storage 116 may also store software 122 to perform RF planning functions utilizing the data stored at 120. In addition, other software, which is not represented in the drawing, may be stored in the mass storage 116, including operating system software and/or other applications that allow the computer 100 to perform other functions in addition to RF planning and the inputting of data used in RF planning. Still further, the mass storage 116 may store one or more data storage structures 124 to store the data which results from operation of the RF planning software. In practice the functions described herein may all be performed in one computer or may be divided among two or more computers that may be in communication with each other and/or may exchange data via removable memory devices such as floppy disks, CD-ROMs, etc. It will be appreciated that all of the software referred to above may be temporarily stored in memory 102 and fetched instruction-by-instruction by the processor 101 to program the processor 101. The software may also be referred to as "program instructions" or "computer readable program code".

FIG. 2 is a high level flow chart that illustrates a process which may be performed in the computer 100. At 202, data required for performing an RF planning function (e.g., for planning the locations and types of components of a wireless LAN) is input. At least some portions of the data input at step 202 may be performed in accordance with principles of the present invention. At 204, the data provided at 202 is used as an input for the RF planning function, which may generally be carried out in accordance with conventional practices.

FIG. 3 is a flow chart that shows some details of the data input process of FIG. 2. At 302, data concerning a building or buildings in which the network is to be installed is provided to the computer 100. The data may include the compositions and locations of building features such as walls, floors, fixed items of equipment, etc. Inputting of this data to the computer 100 may be performed in accordance with conventional practices. At 304, the user inputs to computer 100 the proposed locations of RF signal sources such as point source antennas and/or leaky coaxial cables that may in effect serve as antennas. In part (e.g. as to point source antennas) this location data

5

input step may be performed in a conventional manner. In other respects (e.g., as to leaky coax) this location data input step may be performed in accordance with principles of the present invention, in a manner to be described below.

At **306**, the user inputs to computer **100** characteristics of the RF signal sources. At least in part, this step may be performed in accordance with principles of the present invention, as described below.

FIG. **4** is a flow chart that shows further details of the process of FIGS. **2** and **3**. In particular, FIG. **4**, with its accompanying illustrations in FIGS. **5-8**, shows how data concerning characteristics of directional and/or omnidirectional access points/base stations/antennas may be entered into the computer **100** in regard to step **306** (FIG. **3**) and in accordance with aspects of the invention. At **402**, a reference polar coordinate system **500** (FIG. **5**) is displayed on display **106** (FIG. **1**) as at least a portion of a GUI for RF planning data input. As will be appreciated by those who are skilled in the art, the reference polar coordinate system allows the locations of particular points in a plane to be represented as a coordinate pair (θ, r) , where θ represents the angular direction from the origin and r represents the distance from the origin.

Continuing to refer to FIG. **4**, at **404** an image **602** (FIG. **6**) that represents a radiation pattern characteristic of an antenna/access point/base station is displayed on the display **106** simultaneously with the reference polar coordinate system **500**. It will be observed that the radiation pattern image **600** includes two parts: a polar coordinate system **602** and a pattern region **604**. The pattern region **604** indicates, relative to the polar coordinate system **602**, a radiation pattern generated by the antenna/access point/base station. For example, the radiation pattern indicated by the pattern region **604** may be in a horizontal plane. Data which represents the radiation pattern image **600** may have been loaded into the computer **100** in a number of ways. For example, the radiation pattern image may have been scanned from an antenna data sheet or catalog or the like using the scanner **114** to produce a bitmap or jpeg file of the radiation pattern image. Alternatively, the radiation pattern image may have been downloaded to the computer **100** from a manufacturer's website or loaded into the computer **100** via a removable medium such as a floppy disk, CD ROM or ZIP disk. In some embodiments, the radiation pattern image file, however loaded into the computer **100**, may be opened, and the radiation pattern image may be copied, and then pasted into the same window with the reference polar coordinate system **500**. The opening, copying and pasting operation may be performed by the user in response to a suitable prompt (not shown) issued by the computer **100** upon the displaying of the reference polar coordinate system **500**.

Like a typical object in a drawing application image, the radiation pattern image **600** may be "dragged", i.e., moved from one place to another in the image plane by manipulating a cursor (not shown) using the mouse **108**. In addition, the radiation pattern image **600** includes "handles" **606** which may be manipulated by the cursor and the mouse **108** to "scale" (i.e., to change the size of) the radiation pattern image **600**. As indicated at **406** in FIG. **4**, the user moves and scales the radiation pattern image **600** so that the polar coordinate system **602** of the radiation pattern image **600** is brought into coincidence with the reference polar coordinate system **500**. (As used herein and in the appended claims, two coordinate systems are "in coincidence with" each other if the two coordinate systems exactly coincide with each other in position on a display screen.) The resulting screen display (or a portion thereof) is shown in FIG. **7**. It should be recognized that the reference polar coordinate system may be provided as a background object in the composite image illustrated in FIGS. **6**

6

and **7**, with the radiation pattern image having a degree of transparency such that the reference polar coordinate system is visible through the radiation pattern image; alternatively, the reference polar coordinate system may be a foreground object with a degree of transparency such that the radiation pattern image is visible through the reference polar coordinate system.

At **408** in FIG. **4**, the scale of the r axes of the reference polar coordinate system is defined so as to match the scale of the r axes of the polar coordinate system of the radiation pattern image. For example, a suitable line-drawing tool (not shown) may be used to define a length of line that corresponds to a suitable distance/attenuation scale of the polar coordinate system of the radiation pattern image.

At **410** in FIG. **4**, the user uses the cursor/mouse to mark points **800** on the boundary of the pattern region **604** of the radiation pattern region. The points may be marked by the user positioning the cursor (not shown) at various points along the boundary of the pattern region, and clicking (e.g., once or twice) a button on the mouse at the times when the cursor is located on the boundary. The marked points may be indicated by small circles in a contrasting color, such as red. In this way, the user indicates to the computer **100** the location of the pattern region and the corresponding radiation pattern, relative to the reference polar coordinate system. In some embodiments, a tool or tools may be provided to allow the user to move or delete existing points and/or to add new ones. When the user has completed his or her tracing or outlining of the pattern region with the marked points, he/she may actuate a "submit" button (not shown) or the like in the GUI to indicate completion of entry of data with respect to the (in this case horizontal) radiation pattern. Based on the display data points represented by the marked points, the computer **100** may generate a closed curve, and from that curve may derive (step **412**) numerical data to represent the (in this case horizontal) radiation pattern of the antenna/access point/base station in question.

The process illustrated by steps **402-412** may be repeated (steps **414-424**) with respect to another radiation pattern image, in this case representing the radiation pattern of the antenna/access point/base station in a vertical plane. To all intents and purposes the illustrations in FIGS. **5-8** may also be taken to illustrate steps **414-424**, with the proviso that the pattern region for the vertical radiation pattern image may differ in shape and/or size from the pattern region for the horizontal radiation pattern image. It will further be noted that the vertical radiation pattern image may be displayed simultaneously with the reference polar coordinate system at a time when the horizontal radiation pattern image is not displayed.

At **426**, the computer **100** may generate three-dimensional radiation pattern data for the antenna/access point/base station from the horizontal pattern data derived at step **412** and from the vertical pattern data derived at step **424**. The generation of the three-dimensional pattern data may be done, for example, by a conventional interpolation technique.

The resulting three-dimensional pattern data may be used as an input to the RF planning function represented at **204** in FIG. **2**. For example, the three-dimensional pattern data may be used in RF signal propagation simulations using conventional ray tracing techniques.

It should be understood that the inputting of the vertical pattern data may precede, instead of following, the inputting of the horizontal pattern data.

FIG. **9** is a partial schematic illustration of a "leaky" coaxial cable **900** that may be modeled in the process of FIGS. **2** and **3**. As is customary for a coaxial cable, the cable **900** includes a central conductor **902** and an outer conductive

shield **904**, with a dielectric component **906** that is between the conductor **902** and the shield **904** and that has an annular cross-section. To render the cable **900** “leaky” (and therefore functional as an antenna that can provide signal coverage for an extensive and/or irregularly shaped area), the shield includes openings **908** from which the signal (schematically indicated at **910**) may emanate. In various conventional types of leaky coaxial cables, the openings in the shield may have various shapes, sizes and distributions along the cable and/or around the circumference of the cable.

FIG. **10** is a flow chart that shows further details of the process of FIGS. **2** and **3**, as the same may be performed when a leaky coaxial cable is to be included in a wireless network or the like.

At **1002** in FIG. **10**, a computer drawing tool may be employed with the computer **100** to indicate to the computer (and particularly to the RF planning software **122**), a proposed layout for a leaky coaxial cable to be used in a wireless network. The computer drawing tool may be part of the data input function **118**. The computer drawing tool may be operable (with a mouse, e.g.) in a similar fashion to a straight-line drawing tool included in a conventional computer drawing software package.

FIG. **11** illustrates portions of a graphical user interface that may be displayed by the computer **100** (i.e., by display **106**) in conjunction with step **1002**. An angled line **1102** may be displayed as drawn by the user to represent the proposed layout of the leaky coaxial cable. The angled line **1102** may be superimposed on a map (not shown in the drawing) of a floor of a building in which the wireless network is to be installed.

The angled line **1102** may be formed of a number of straight line segments (in this particular example, line segments **1104**, **1106**, **1108**, **1110** and **1112**). Each of the line segments **1104**, **1106**, **1108**, **1110**, **1112** may represent, and indicate the location of, a respective segment of the leaky cable represented by the angled line **1102**.

In addition, as part of the data entry process, and in representing the layout of the leaky cable, the user may indicate, with a suitable drawing tool from the data input function software **118** (FIG. **1**), the proposed location of a signal source (represented at **1114** in FIG. **11**) which is to inject the signal into the leaky cable. The location of the signal source is the point (sometimes referred to herein as the “start point”) from which signal attenuation along the cable will be calculated.

As indicated at **1004** in FIG. **10**, a process loop may be performed with respect to each “point of interest”, where a point of interest is a point in space (in the building in which the wireless network is to be installed) for which it is desired to determine or estimate what level of signal coverage (signal strength) will be provided by the leaky cable. Within the process loop indicated by step **1004**, a nested process loop may be performed for each segment of the proposed leaky cable layout, with the nested process loop being indicated by step **1006**. The cable segments, as noted above, are as indicated by the straight line segments shown in the display (FIG. **11**). In the nested process loop, a metric, which will be referred to as a “shortest radio distance metric”, is calculated for the current cable segment with respect to the current point of interest. Calculation of the shortest radio distance metric is indicated at step **1008** within the nested process loop, and proceeds as follows:

First, the nearest point on the current segment to the current point of interest is determined.

Second, signal attenuation along the cable from the start point to the nearest point is calculated. This may be done using the proposed cable layout and signal source loca-

tion as indicated by the angled line (**1102**) in FIG. **11** and the location of the signal source block (**1114** in FIG. **11**). The calculation of signal attenuation along the cable may use an attenuation constant that may be provided by the manufacturer of the leaky cable as part of the technical specifications for the leaky cable.

Third, the attenuation in free space is calculated between the nearest point on the current segment and the current point of interest. This quantity may be calculated in accordance with conventional practices. In some cases, in some embodiments, the calculation of “free space” attenuation may also take into account objects located between the nearest point on the current segment and the current point of interest, and may thus take into account the additional attenuation due to the object. In some embodiments, calculations may be performed relative to points other than the nearest point on the current segment, if an object is present between the closest point on the current segment and the current point of interest, to determine whether the other points result in a smaller radio distance metric because there may be no object between the other point on the current segment and the current point of interest.

Fourth, the shortest radio distance metric is calculated as the sum of the free space attenuation and the attenuation along the cable.

At **1010** in FIG. **10**, the cable segment having the smallest value for its shortest radio distance metric is selected to be the cable segment that is likely to produce a dominant level of signal irradiation with respect to the current point of interest. (A cable segment produces a “dominant” level of signal irradiation with respect to a point of interest if the level of irradiation estimated to be produced by the cable segment for the point of interest is greater than the level of irradiation estimated to be produced by any other cable for the point of interest.)

To provide some examples, consider first the point of interest represented by cross-mark **1116** in FIG. **11**. This point of interest is equidistant from the cable segments represented respectively by straight line segments **1104** and **1106**, so that the free space attenuation from those two cable segments to the point of interest is likely to be the same. Since the cable segment represented by straight line segment **1104** is closer to the signal source (indicated at **1114**; i.e., the start point) than the cable segment represented by straight line segment **1106**, the attenuation along the cable to the nearest point of the first cable segment (represented at **1104**) to the point of interest will be less than the attenuation along the cable to the nearest point of the second cable segment (represented at **1106**) to the point of interest. Consequently the first cable segment will have the smaller value for its shortest radio distance metric and will be determined to be the dominant cable segment.

In a second example, consider the point of interest represented by cross-mark **1118** in FIG. **11**. This point of interest is much closer to the second cable segment (indicated at **1106**) than to any of the other cable segments. Consequently, the free space attenuation to the point of interest is much less for the second cable segment, which will be determined to be the dominant cable segment.

At **1012**, as part of the outer process loop indicated by step **1004**, the estimated effective received power level is calculated for the current point of interest. This calculation is performed by subtracting the following three quantities from the proposed input power level for the leaky cable:

(1) Coupling loss from the inner conductor to the outer cable shield; this is a constant that is likely to be pro-

vided by the manufacturer of the leaky cable as part of the technical specifications for the cable.

(2) Attenuation along the cable from the start point to the closest point (on the dominant segment) to the current point of interest.

(3) Attenuation in free space from the closest point (on the dominant segment) to the current point in interest.

It will be appreciated that the process of FIG. 10 may incorporate functions of both the data input software 118 (FIG. 1) and the RF planning software 122, and/or that the estimated received power levels at the points of interest may be provided as an input to an RF planning function for a wireless data network.

Although the system has been described in detail in the foregoing embodiments, it is to be understood that the descriptions have been provided for purposes of illustration only and that other variations both in form and detail can be made thereupon by those skilled in the art without departing from the spirit and scope of the invention, which is defined solely by the appended claims.

What is claimed is:

1. A method comprising:

displaying a first polar coordinate system on a display screen;

displaying a first radiation pattern image on the display screen, the first radiation pattern image including a second polar coordinate system and a first pattern region indicative of a radiation pattern generated by an antenna in a horizontal plane;

scaling and moving said first radiation pattern image to bring the second polar coordinate system into coincidence with the first polar coordinate system;

defining a scale for the first polar coordinate system to reflect a parameter of the first radiation pattern image;

marking points on a boundary of the first pattern region;

deriving horizontal pattern data from said marked points;

displaying a second radiation pattern image on the display screen together with the first polar coordinate system at a time when the first radiation pattern image is not displayed on the display screen, the second radiation pattern image including a third polar coordinate system and a second pattern region indicative of a radiation pattern generated by the antenna in a vertical plane;

scaling and moving the second radiation pattern image to bring the third polar coordinate system into coincidence with the first polar coordinate system;

defining a scale for the first polar coordinate system to reflect a parameter of the second radiation pattern image;

marking points on a boundary of the second pattern region;

deriving vertical pattern data from said points marked on the boundary of the second pattern region; and

generating three-dimensional pattern data from said horizontal and vertical pattern data.

2. A method according to claim 1, further comprising:

providing the three-dimensional pattern data as an input to an RF planning function for a wireless data network.

3. A method according to claim 1, wherein the marking points includes clicking a mouse button when a cursor is located on the boundary of the first or second pattern region.

4. A method according to claim 1, wherein said displaying of the second radiation pattern image occurs after said marking of points on the boundary of the first pattern region.

5. A method according to claim 1, wherein said displaying of the first radiation pattern image occurs after said marking of points on the boundary of the second pattern region.

6. A method according to claim 2, wherein said marking points includes clicking a mouse button when a cursor is located on the boundary of the first or second pattern region.

7. A method according to claim 2, wherein said displaying of the second radiation pattern image occurs after said marking of points on the boundary of the first pattern region.

8. A method according to claim 2, wherein said displaying of the first radiation pattern image occurs after said marking of points on the boundary of the second pattern region.

9. A method according to claim 3, wherein said displaying of the second radiation pattern image occurs after said marking of points on the boundary of the first pattern region.

10. A method according to claim 3, wherein said displaying of the first radiation pattern image occurs after said marking of points on the boundary of the second pattern region.

11. A method according to claim 4, wherein said displaying of the first radiation pattern image occurs after said marking of points on the boundary of the second pattern region.

12. A method according to claim 1, further comprising: receiving said first radiation pattern image for display on the display screen.

13. A method according to claim 12, wherein the receiving said first radiation pattern image comprises downloading said first radiation pattern image from a website or storage medium.

14. A method according to claim 2, further comprising: receiving said first radiation pattern image for display on the display screen.

15. A method according to claim 14, wherein the receiving said first radiation pattern image comprises downloading said first radiation pattern image from a website or storage medium.

16. A method according to claim 4, further comprising: receiving said first radiation pattern image for display on the display screen.

17. A method according to claim 16, wherein the receiving said first radiation pattern image comprises downloading said first radiation pattern image from a website or storage medium.

18. A method according to claim 5, further comprising: receiving said first radiation pattern image for display on the display screen.

19. A method according to claim 18, wherein the receiving said first radiation pattern image comprises downloading said first radiation pattern image from a website or storage medium.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,583,855 B2
APPLICATION NO. : 11/361142
DATED : September 1, 2009
INVENTOR(S) : Dundar et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

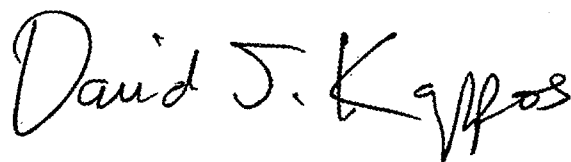
On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b)
by 741 days.

Signed and Sealed this

Fourteenth Day of December, 2010

A handwritten signature in black ink that reads "David J. Kappos". The signature is written in a cursive style with a large, stylized "D" and "K".

David J. Kappos

Director of the United States Patent and Trademark Office